Space Weather Technical Forecast

Issued on Saturday, 18 December 2021 at 00:35 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Daily Chance of M-class flares, potentially increasing over the UTC weekend.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar Activity has been Moderate in the last 24 hours, with an impulsive M1.2 at 17/0051UTC originating from sunspot region AR2911 in the northeast quadrant. This sunspot group was relatively dynamic in the 24 hours, even if not appearing overtly complex in its eventual Cai/Beta classification.

Including the above 2911, there remain six numbered sunspot regions on the visible disc, with the southeastern quadrant in particular remaining heavily populated and strongly polarised. As a general trend, rates of growth appeared to slow in all spots in the last 24 hours relative to the preceding 24, with slight spreading the main behaviour seen the nominally most threatening sunspots AR2907 and 2908, which both ended the period as Dai/Beta groups. To their east, 2909 remained a stable Dso/Beta, while 2906 and 2910 in the western hemisphere both showed slight decay to end as Cri/Beta and Bxo/Beta respectively.

No Earth-directed Coronal Mass Ejections (CMEs) were observed in available satellite imagery for the period, although a CME was observed heading north and behind the Earth in its orbit into the UTC evening on both STEREO A and Lasco imagery.

Solar Wind / Geomagnetic Activity: Solar winds, as measured by the DSCOVR satellite at L1 were reflective of a gradual exit from the influence of a negative polarity high speed stream, thought to be that from coronal hole 32. The solar wind speed gradually decreased from an early high near 460 to approach 360km/s by the period's end. The solar wind density was stable within mid-single figures ppcc, while the IMF peaked at just 5nT with a north-south variation between +/-3nT. The phi angle remained mostly negative (towards the sun) but with a more variable character into the UTC evening.

The net result of the above solar wind measures was provisionally Quiet geomagnetic activity throughout the 24 hours, with an early peak Kp of '2o' seen in the 00-03UTC interval.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) remained at Background levels.

The high energy electron flux (greater than 2 MeV) was at mainly Background levels, with the associated 24-hour integrated fluence well below the Active threshold. A fluence of 1.79e6 was observed at 18/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to continue mainly Low, with the Chance (30%) of further isolated M-class flares, and a Slight (5%) Chance of an X-class flare. Flare probabilities

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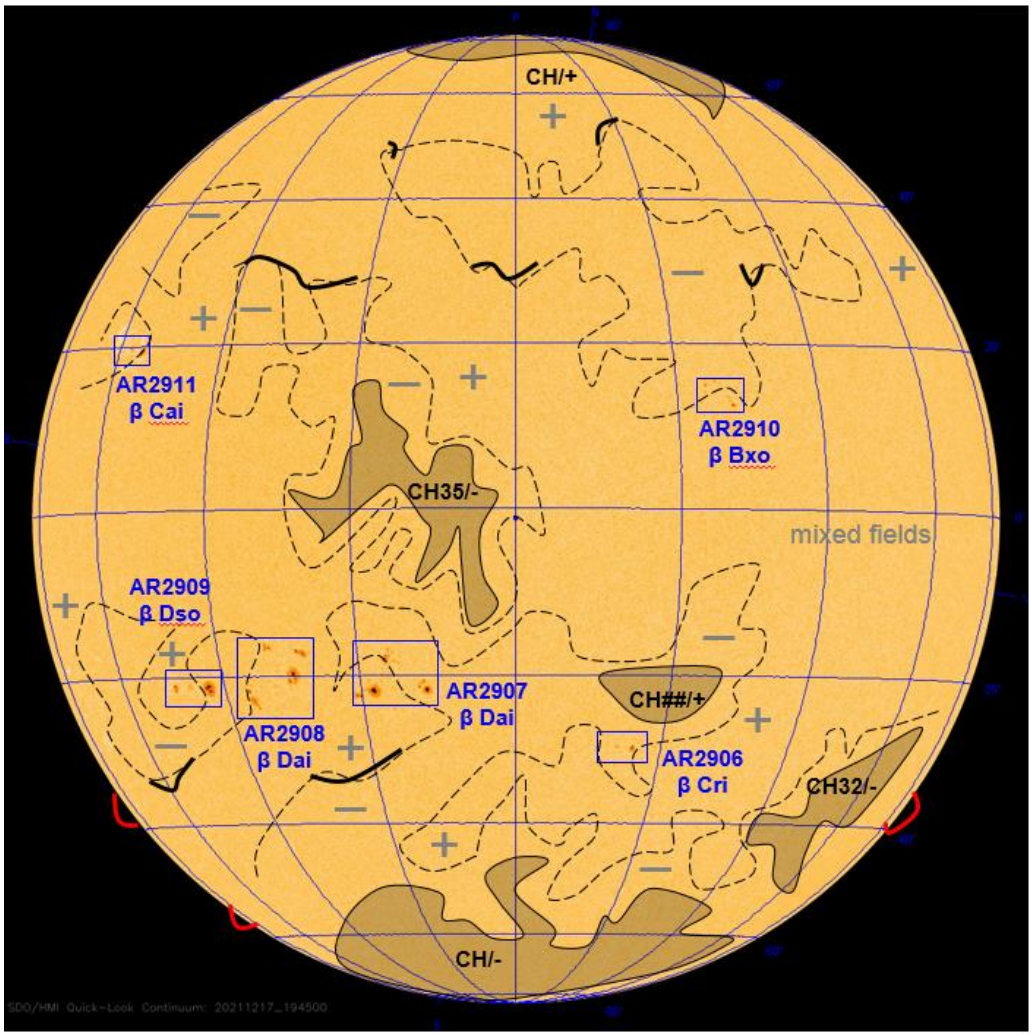
may increase a little in the coming days (to 40 and 10% respectively), with further potential active regions likely to rotate around the east limb and none leaving over the west.

Solar Wind / Geomagnetic Activity: No CMEs feature in the current forecast period. Earth has recently exited a high speed stream from CH32 to leave Quiet geomagnetic conditions. There is now thought to be a chance of some influence from the small CH36 later in the UTC weekend, perhaps peaking at Active, before reverting to Quiet once again. Finally, there is a possible late peak in activity should CH35 arrive on day four, Tuesday 21 December, signposted by a 5% Slight Chance of G1.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels, although with a slight increasing risk as the active regions transit towards the western solar hemisphere.

The high energy (greater than 2 MeV) electron flux, as observed by GOES-16, is expected to be at Background to Moderate levels, perhaps with a slight rising trend in the next day or so. The associated fluence is expected to remain below the Active threshold.

Figure 1. Solar Analysis Valid 17/1945UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

No Earth-directed CMEs feature in this forecast.

Earth's exit from coronal hole 32's high speed stream to end the working week had been thought to potentially leave the Earth in a slow regime for the coming four days. CH35's arrival at Earth is uncertain but will probably fall outside the forecast period (for lack of an analogue on the previous rotation and no effect at STEREO A as of yet). STEREO A PLASTIC data in the past three days does however suggest a possible modest enhancement to near 500km/s, which may be the result of the much-reduced CH36/-, which is a vestigial remnant of a much larger coronal hole from 27 days ago (reaching the upper-600s of km/s). The emergence of a train of sunspot regions in this location appears to have largely closed the coronal hole, but STEREO A data perhaps implies that it survives in some form.

In a mainly Quiet forecast, there is therefore now considered a Chance of some Active intervals later in the UTC weekend, perhaps also creeping into Monday 20 December, day three. CH35 may also make a late appearence, giving a token 5% Slight Chance of G1 on day four, Tuesday 21 December, although with this being the winter solstice any effect will probably be very muted.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	1	1	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Nil.

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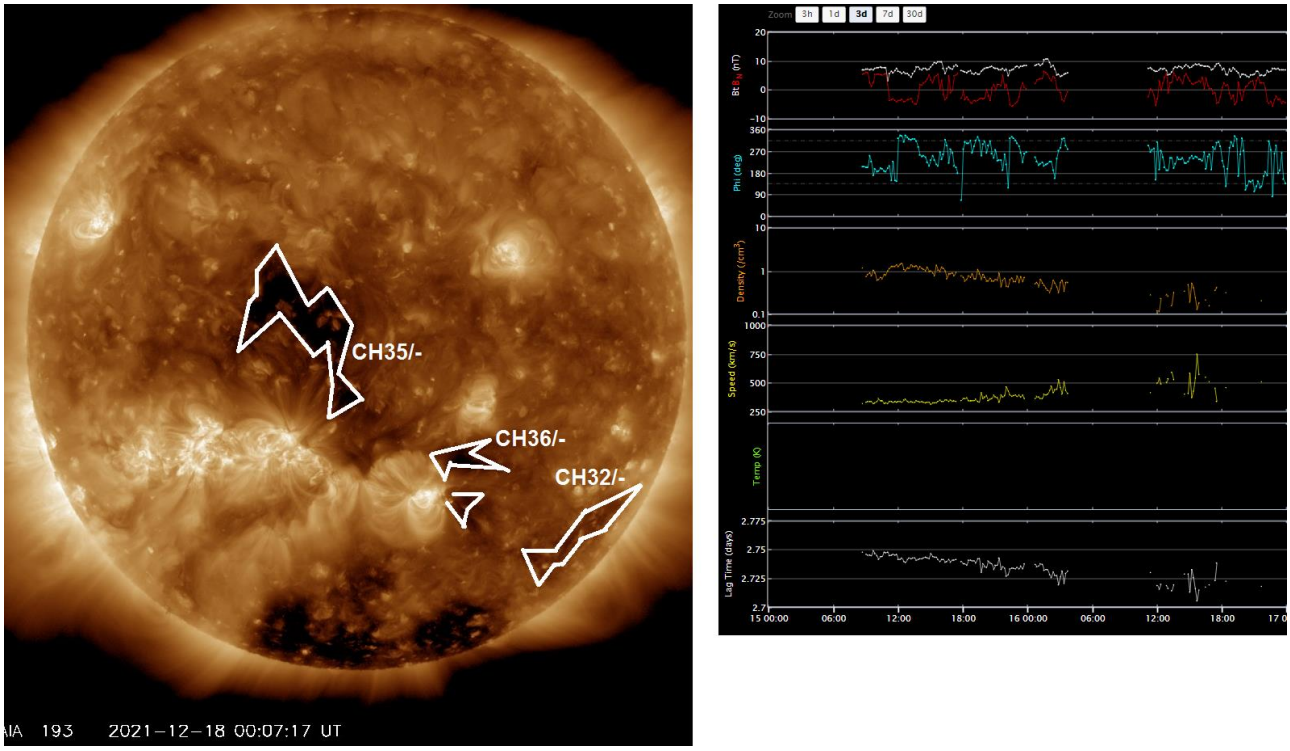
Figure 2: AIA 193 image from 18/0017UTC showing the current configuration of coronal holes. CH36/- in particular carries low confidence, however is perhaps the most liekyl explanation for hints of a roughly 500km/s high speed stream-like signature at STEREO A two days ago (MAG and PLASTIC traces shown right).



Radio Blackouts - X-Ray Flares:

The current Earth-facing disc is replete with sunspots at present, especially the eastern solar hemisphere. This trend appears to continue onto the far side over the eastern limb, with soundings and STEREO A EUVI 195 imagery both suggesting that several bright flux regions lie narrowly over the horizon. Given that none of the current front-side regions leave the disc in the four days, any arrivals in the east should add to the risk of X-ray flares. The degree to which this occurs remains to be seen, however the coming UTC weekend ought to reveal some new regions here for analysis.

At present, the complexity on paper of the current front side groups is still thought to offer a daily Chance of M-class flares and a Slight Chance of X-class, with C-class flares Expected (90%).

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	30	40	40	40
Very Active	R3 to R5 X Class	No	5	10	10	10

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Figure 3: 18/2319UTC composite image of the sun comprising AIA 171 and HMIBC imagery, showing a cluster of active regions in the southeastern quadrant of the sun, as well as potential flux loops from further such regions over the southeastern (and perhaps northeastern) limb.

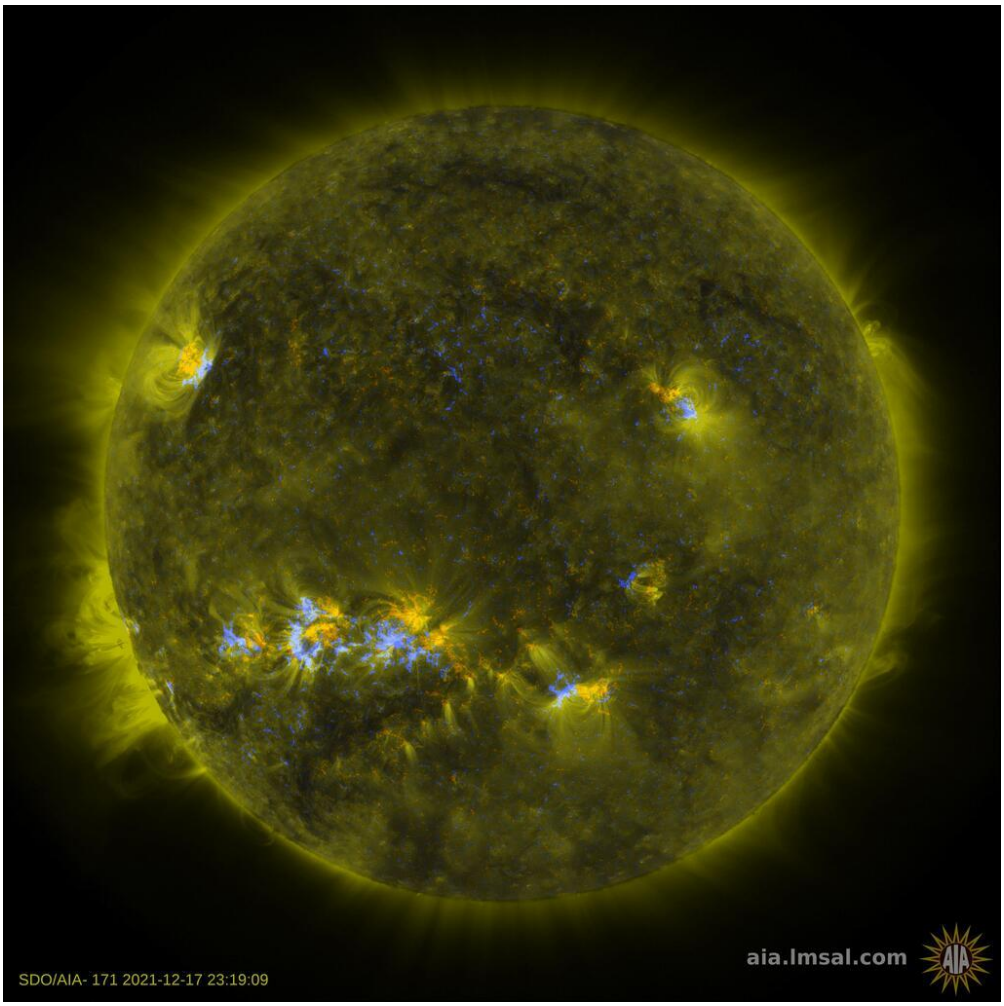
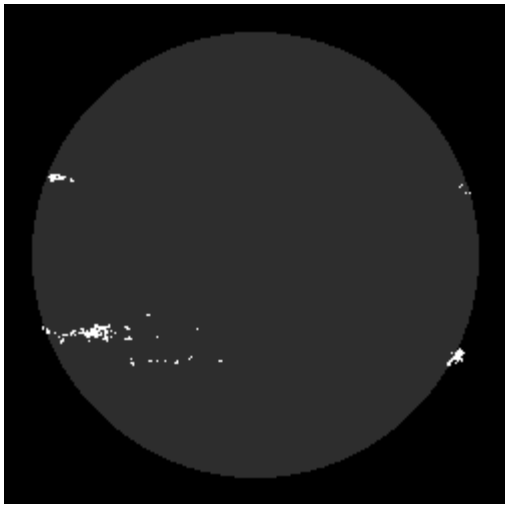


Figure 4: SIDC ROB image of X-ray flare locations over the preceding two weeks, with these heavily concentrated in the southeast and with many of these tied to spots on the current Earth-facing disc.



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Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is currently expected to remain at Background levels.

Increasing sunspot activity may warrant a slight increase in the chance of S1 radiation storms over the next few days, though at present the most significant active regions are in the eastern hemisphere of the solar disc.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	2	2	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2 MeV) electron flux, as observed by GOES-16, is currently at Background to Moderate levels. At the time of writing there has been a very muted response in electrons at GEO to the lifting of geomagnetic activity from CH32. Any resulting rise ought to now be imminent if indeed it occurs at all, with the peak risk for fluence probably coming over the coming UTC weekend, albeit a very low risk. CH32 was weaker than its predecessor from last rotation (where Active fluence was not achieved), and any reaction from coronal hole 36 is likely to be similarly restrained for being smaller and Earth's being relatively nearer the solstice.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	5	5	5
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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